

CLAIMS

What is claimed is:

1. A freeze tolerant fuel cell power plant for generating an electrical current from hydrogen containing reducing fluid fuel and oxygen containing oxidant reactant streams, the plant comprising:
 - 5 a. at least one fuel cell (12) including a coolant inlet (14) and a coolant outlet (16) for directing a water immiscible fluid and a water coolant to flow through the fuel cell (12);
 - 10 b. a coolant loop (18) including a freeze tolerant accumulator means (22) secured in fluid communication with the fuel cell coolant outlet (16) for storing and separating the water immiscible fluid and the water coolant, a direct contact heat exchanger (56) secured in
15 fluid communication with the accumulator means (22) and the fuel cell coolant inlet (14), and a coolant circulating means (21) secured in fluid communication with a coolant passage (20) of the coolant loop (18) for circulating the
20 water immiscible fluid and the water coolant through the coolant loop (18);
 - 25 c. a radiator loop (84) including a radiator (86) secured in fluid communication between a water immiscible fluid discharge (91) and water immiscible fluid inlet (90) of the direct contact heat exchanger (56) that removes heat from the water immiscible fluid passing through the radiator (86), and a radiator pump (92) secured to the radiator loop (84) for
30 circulating the water immiscible fluid through the radiator (86) and direct contact heat exchanger (56); and,

d. a direct contact heat exchanger by-pass system means (200) for directing flow of coolant from the coolant loop (18) through the radiator (86) and back to the coolant loop (18) by-passing the direct contact heat exchanger (56).

2. The freeze tolerant fuel cell power plant (10) of claim 1, wherein the direct contact heat exchanger by-pass system means (200) comprises by-pass valve means for directing the coolant to flow from the coolant loop (18) through a by-pass feed line (201) to the radiator (86) and from the radiator (86) through a by-pass return line (202) back to the coolant loop (18) by-passing the direct contact heat exchanger (56).

3. The freeze tolerant fuel cell power plant (10) of claim 2, wherein the direct contact heat exchanger by-pass system means (200) further comprises water immiscible fluid isolation valve means for restricting flow of the water immiscible fluid from the direct contact heat exchanger (56) and the radiator loop (84) into the coolant loop (18) whenever the by-pass valve means are directing flow of the coolant directly from the coolant loop (18) to the radiator (86) and back to the coolant loop (18) by-passing the direct contact heat exchanger (56).

4. The freeze tolerant fuel cell power plant (10) of claim 2, wherein the by-pass valve means comprise a coolant loop by-pass feed valve (204) for selectively directing flow of the coolant from the coolant loop (18) into the by-pass feed line (201), a direct contact heat exchanger feed valve (54) and direct contact heat exchanger by-pass valve (83) for selectively prohibiting

flow of the coolant into the direct contact heat exchanger (56), and a radiator loop by-pass valve (206)
10 for selectively directing the coolant discharged out of the radiator (86) into the by-pass return line (202).

5. The freeze tolerant fuel cell power plant (10) of claim 3, wherein the water immiscible fluid isolation valve means comprise a direct contact heat exchanger discharge valve (208) secured in fluid communication with
5 an outlet of the direct contact heat exchanger (56) for selectively prohibiting flow of the coolant out of the heat exchanger (56), and a radiator inlet valve (210) secured in fluid communication between the by-pass feed line (201), the direct contact heat exchanger (56) and
10 the radiator (86) for selectively directing flow from either the by-pass feed line (201) or the heat exchanger (56) into the radiator (86).

6. The freeze tolerant fuel cell power plant (10) of claim 1, wherein the water immiscible fluid is selected from the group consisting of silicones, silicone copolymers, substituted silicones, siloxanes,
5 polysiloxanes, substituted siloxanes or polysiloxanes and mixtures thereof.

7. The freeze tolerant fuel cell power plant (10) of claim 1, wherein the water immiscible fluid is selected from the group consisting of perfluorocarbons, hydrofluoroethers and mixtures thereof.

8. The freeze tolerant fuel cell power plant (10) of claim 1, wherein the water immiscible fluid is selected from the group consisting of alkanes, alkenes, alkynes having six or more carbon atoms and mixtures thereof.

9. The freeze tolerant fuel cell power plant (10) of claim 1, wherein the water immiscible fluid has a freezing temperature equal to or less than minus twenty degrees Celsius, has a surface tension of less than or equal to 35 dynes/cm, and has a solubility in water of less than 0.1 percent.

10. The freeze tolerant fuel cell power plant (10) of claim 1, wherein the water immiscible fluid has a freezing temperature equal to or less than minus twenty degrees Celsius, has a surface tension of less than or equal to 20 dynes/cm, and has a solubility in water of less than 0.1 percent.

11. A method of operating a freeze tolerant fuel cell power plant (10), the power plant (10) including at least one fuel cell (12) having a coolant inlet (14) and a coolant outlet (16) for directing a water immiscible fluid and a water coolant to flow through the fuel cell (12), a coolant loop (18) including a freeze tolerant accumulator (22) secured in fluid communication with the fuel cell coolant outlet (16) for storing and separating the water immiscible fluid and the water coolant, and a coolant pump (21) secured in fluid communication with a coolant passage (20) of the coolant loop (18) for circulating coolant through the coolant loop (18), the method comprising the steps of:

- a. securing a direct contact heat exchanger (56) in fluid communication with the accumulator (22) and the fuel cell coolant inlet (14);
- b. providing a radiator loop (84) including a radiator (86) secured in fluid communication between a water immiscible fluid discharge (91)

20 and water immiscible fluid inlet (90) of the
 direct contact heat exchanger (56) that removes
 heat from the water immiscible fluid passing
 through the radiator (86), a radiator pump (92)
 secured to the radiator loop (84) for
25 circulating the water immiscible fluid through
 the radiator (86) and direct contact heat
 exchanger (56); and,
 c. selectively directing flow of the coolant from
 the coolant loop (18) through the radiator (86)
30 and back to the coolant loop (18) by-passing
 the direct contact heat exchanger (56).

12. The method of claim 11, comprising the further steps
of restricting flow of the water immiscible fluid from
the direct contact heat exchanger (56) and the radiator
loop (84) into the coolant loop (18) whenever the coolant
5 is directed to flow directly from the coolant loop (18)
to the radiator (86) and back to the coolant loop (18)
by-passing the direct contact heat exchanger (56).

13. The method of claim 11, comprising the further step
of directing flow of the coolant from the coolant loop
(18) through the radiator (86) and back to the coolant
loop (18) by-passing the direct contact heat exchanger
5 (56) whenever an ambient temperature is greater than
thirty degrees Celsius.